International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN(P): 2249–6890; ISSN(E): 2249–8001
Vol. 9, Issue 6, Dec 2019, 1003–1020
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EXPERIMENTAL ANALYSIS OF MECHANICAL PROPERTIES, WEAR AND CORROSION CHARACTERISTICS OF IS600/3 GRADE DUCTILE IRON CASTING

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ABSTRACT

Ductile iron castings, that comply with IS600/3 grade is used for the current study. On the basis of earlier research, the castings were austenitised at 900°C for 120 minutes duration and quenched in a bath of salt containing potassium nitrate and sodium nitrate in the ratio of 55:45 and held at temperature of 310°C for the duration of 120 minutes in an austempered treatment process. The outcome of above procedure was austempered ductile iron casting, which comprise graphite nodules in a matrix of bainite [1, 2].

The outcome of heat treatment process, after making the required specimens in both conditions (i.e. as cast condition & heat treated condition) on mechanical properties [13], wear and corrosion characteristics were investigated and a comparison was made with the as cast state of ductile iron. Properties such as UTS, percentage elongation, hardness values and impact strength values were investigated. Dry sliding wear test was attempted to measure the weight loss of prepared samples in both conditions (i.e. as cast condition & heat treated condition); using machine with pin and rotating disc arrangement. Dry sliding wear test was conducted by applying three loads condition (i.e. 300gm, 400gm and 500gm) and three speeds conditions (i.e. 950r.p.m, 1430r.p.m and 2130r.p.m). Corrosion test was conducted to investigate corrosion rate at temperatures, 35°C and 45°C for increasing testing time from 2 hours to 24 hours.

The outcome of the study indicates that the heat treated specimens have higher UTS (25% increase), percentage elongation (27.88% increase) and hardness (10.60% increases) in comparison to the as cast specimen. From the wear test, it has been found that heat treated samples have excessive resistance to wear in comparison to the as cast samples and corrosion rate in heat treated testing samples are less in comparison to as-cast testing samples.

KEYWORDS: Austempered Ductile Iron (A.D.I), Corrosion, Ductile Iron (D.I), Heat Treatment (H.T) & Dry Sliding Wear (D.S.W)

Received: Sep 20, 2019; **Accepted:** Oct 10, 2019; **Published:** Dec 07, 2019; **Paper Id.:** IJMPERDDEC201984

Original Article

1. INTRODUCTION

Ductile Iron casting comprises of graphite in the shape of nodules/spheroids in a matrix of ferrite/pearlite. The mechanical properties of ductile iron consist of properties of cast iron (C.I) as well as steel. Ductile Iron with varying microstructure can be achieved by altering the any treating condition during melting process. By altering any parameter, a suitable ductile iron casting as per our needs and particular use can be gated. For improving mechanical properties of the ductile iron, it can be treated with alloying elements or can be heat treated to bring the changes. Commonly, austempering heat treatment process can be employed on ductile iron and hence known as "Austempered DuctileIron" or "A.D.I". A.D.I has established its application in a broad range of components [5, 6] for great number of engineering sectors such as automobile sector, railways, agriculture, construction etc.

Dry sliding wear is a dominant characteristics assess in materials to determine its feedback to experience the erosion of material by rubbing or by other action [10, 11].It is a continuous, unintended erosion of material when two surfaces meet together under applying normal load condition and relative movement between the mating surfaces. Many Indian foundries are developing ductile iron on a commercial scale for the last three-decades [12].

However, the growth of A.D.I in India is still in nascent state. Hence, in the present research work, ductile iron that complies with IS600/3grade was used for the finest states. Hence, in this study, a step by step investigation was taken for determining mechanical properties, wear and corrosion characteristics at varying loads and speeds [1, 2].

2. EXPERIMENTAL DETAILS

2.1 Hardness Studies

Hardness measurements of the test sample were carried out using Brinell hardness tester with 10 mm diameter ball indenter and 3000 Kg load. The average value of four measurements at different locations of the cross section area was taken for the Brinell hardness tester [3, 4].

2.2 Impact Studies

Impact studies were held on impact testing machine having Izod and Charpy type adjustment. The impact strength for specimens in as cast condition and heat-treated condition will be evaluated [5–6].

2.3 Dry Sliding Wear Test

In dry sliding condition, wear was assessed using pin-on-disc wear testing machine EN-24 steel wear disc of 300 mm, diameter with 5 micron surface finish was used. The pin made of as-cast ductile iron specimen and austempered ductile iron specimen was used. The disc was mounted on a shaft and connected to the motor. The speed could be varied by means of pulley-belt arrangement. The loading was done in an indirect method [7].

By allowing the sample to rub on hardened disc for varying loads and speeds condition, the samples were taken out at constant period and weight was taken for record. The test was held at three specified loads and speeds in as cast and heat treated state of metal [8, 9].

2.4 Corrosion Test

Corrosion test was held on standard salt spray fog type corrosion testing equipment as per ASTM standard B117specification. The corrosion rate of the specimen was calculated using following formula [14].

$$\text{Corrosion rate (M.P.Y)} = \frac{534 \times W}{p.A.T}$$

where,

W-Loss of weight loss in mg,

p-Sample density in gm/cc,

A-Area of sample in mm^2,

T-Testing time in hr.

Also, loss of weight procedure was used to determine the corrosion of the testing sample [15, 16].

3. RESULTS

3.1 Mechanical Properties

Table 1 shows the different mechanical properties such as hardness values, impact energy values (in kg-m) for Izod and Charpy test, ultimate tensile strength values (in N/mm2) and percentage elongation in as cast and heat treated state.

Table 1: Detail Report of Mechanical Properties in as Cast and Heat Treated State

Mechanical Properties	Condition/State		
	As Cast	Heat Treated	Percentage Increase
B.H.N(Hardness Values)	253	283	10.6
Impact Energy values (kg-m), Izod test	2	1.35	32.5
Impact Energy values(kg-m), Charpy test	3.65	1.05	71.23
UTS (N/mm2)	588.5	784.7	25
% Elongation	3	4.16	27.88

Figure 1 shows the variation of hardness values in as cast and heat treated state. It can be seen from Figure 1 that the hardness values increase for heat treated specimen as compared to as cast specimen.

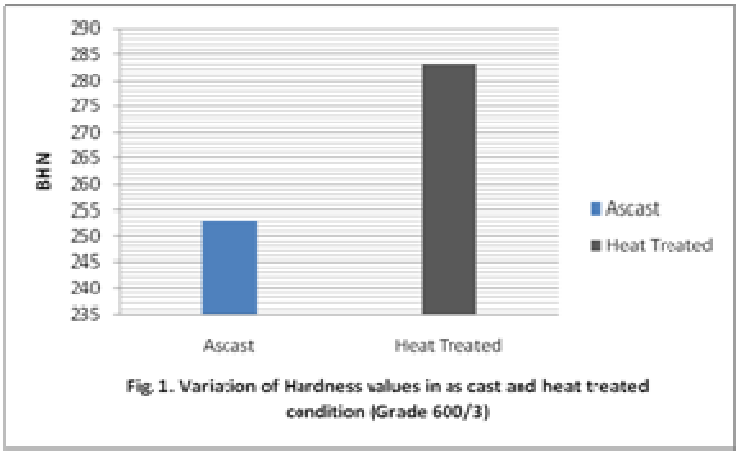

Figure 1: Variation of Hardness Values in as Cast and Heat Treated Condition (Grade 600/3).

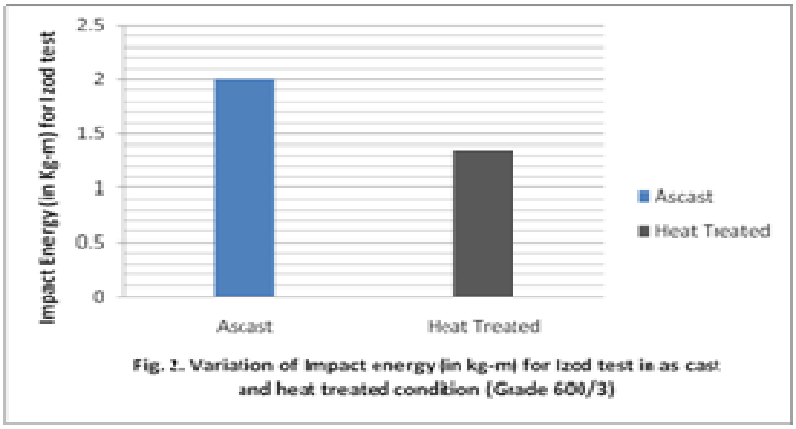

Figure 2: Variation of Impact Energy (in Kg m) for Izod test in as Cast and Heat Treated Condition (Grade 600/3).

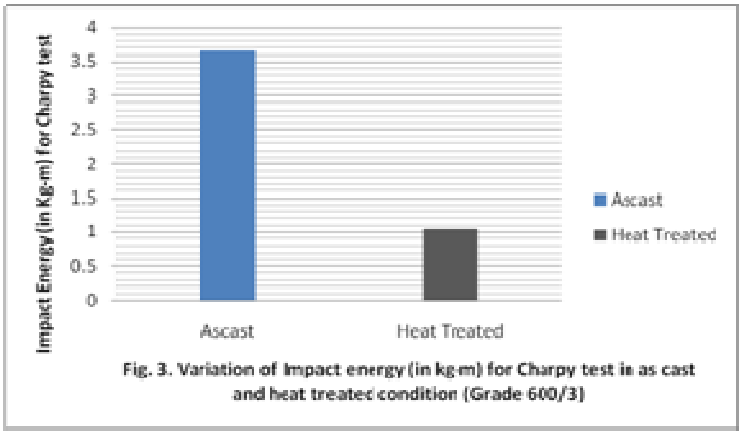

Figure 3: Variation of Impact Energy (in Kg m) for Charpy Test in as Cast and Heat Treated Condtion (Grade 600/3).

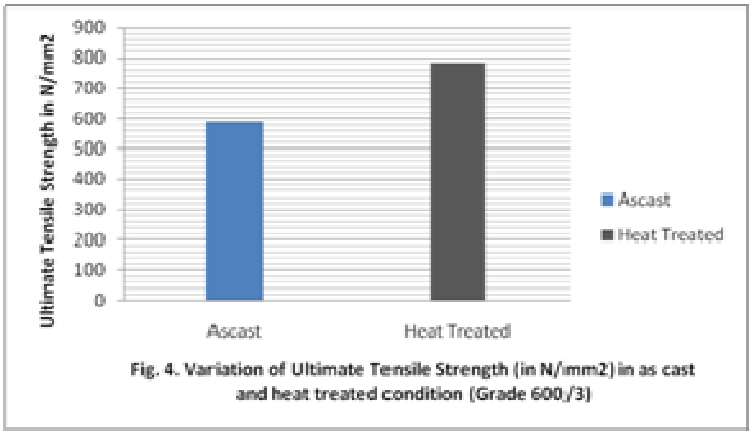

Figure 4: Variation of Ultimate Tensile Strength (in N/mm2) in as Cast and Heat Treated Condition (Grade 600/3).

Figure 2 and Figure 3 shows the variation of impact energy (in kg-m) for izod and charpy test respectively in as cast and heat treated condition. It can be seen from the figure that the impact energy values decreases for heat treated speecimen, as compared to as cast specimen.

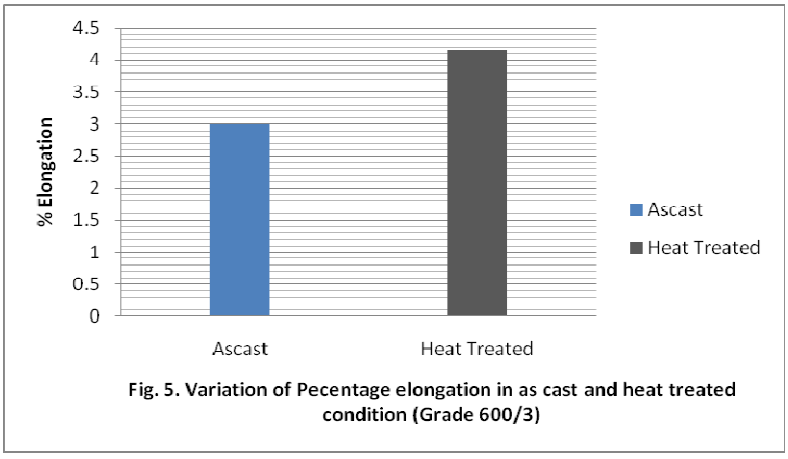

Figure 5: Variation of Percentage Elongation in as Cast and Heat Treated Condition(Grade 600/3).

Figure 4 and Figure 5 shows the variation of U.T.S values and percentage elongation values respectively in as cast and heat treated condition. It can be seen from figure 5 that the ultimate tensile strength and percentage elongation increases for heat treated specimen as compared to as cast specimen.

3.2 Dry Sliding Wear

Table 2 shows the outcome of different speeds on wear test at constant load 300gm in as cast and heat treated state for a testing duration of 20 minutes. It can be seen from Table 2, wear is less in case of heat treated specimens as compared to as cast ones.

Table 2: Outcome of Applied Speeds on Wear Test and Applied Constant Load 300gm in as Cast and Heat Treated State (after 20 minutes)

Speed in r.p.m	Condition/State-Dry Sliding Wear	
	As cast Wear (in mm)	Heat Treated Wear(in mm)
950	0.13	0.11
1430	0.15	0.13
2130	0.19	0.16

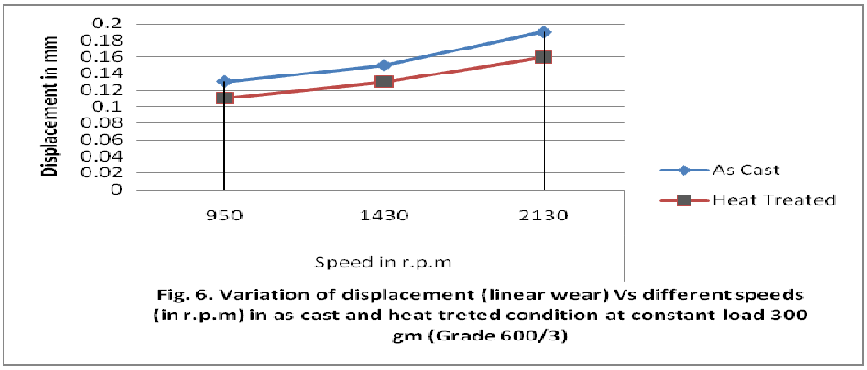

Figure 6: Variation of Displacement (Linear Wear) Vs Different Speeds (in r.p.m) in as Cast and Heat Treated Condition at Constant Load 300gm (Grade 600/3).

Figure 6 shows variation of displacement (linear wear) versus different speeds (in r.p.m) in as cast and heat treated state & applied constant load 300 gm. It can be seen from this figure that the linear wear is less for heat treated specimen as compared to as cast ones.

Table 3 shows the outcome of different speeds on wear test at constant load of 400gm in as cast and heat treated state for a testing duration of 20 minutes. It can be seen from table wear that it is a less in case of heat treated specimens as compared to as cast ones.

Table 3: Outcome of Applied Speeds on Wear Test and Applied Constant Load 400gm in as Cast and Heat treated State (after 20minutes).

Speed in r.p.m	Condition/State-Dry Sliding Wear	
	As Cast, Wear (in mm)	Heat Treated, Wear(in mm)
950	0.18	0.15
1430	0.23	0.2
2130	0.3	0.27

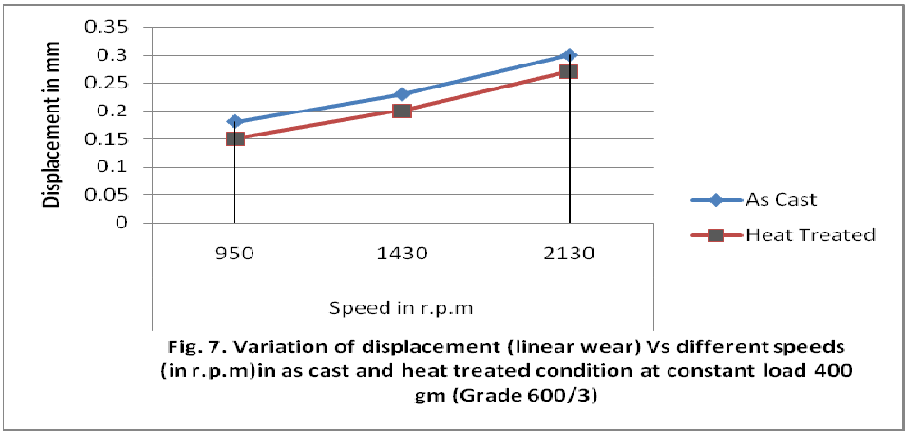

Figure 7: Variation of Displacement (Linear Wear)Vs Different Speeds (in r.p.m)in as Cast and Heat Treated Condition at Constant Load 400gm (Grade 600/3).

Figure 7 shows variation of displacement (linear wear) versus different speeds (in r.p.m) in as cast and heat treated state & applied constant load 400 gm. It can be seen from the figure that the linear wear is less for heat treated specimen as compared to as cast ones.

Table 4 shows the outcome of different speeds on wear test at constant load 500gm in as cast and heat treated state for a testing duration of 20 minutes. It can be seen from table wear that it is less in case of heat treated specimens as compared to as cast ones.

Table 4: Outcome of Applied Speeds on Wear Test and Applied Constant Load 500gm in as Cast and Heat Treated State (after 20 minutes)

Speed in r.p.m	Condition/State-Dry Sliding Wear	
	As Cast Wear (in mm)	Heat Treated Wear(in mm)
950	0.3	0.26
1430	0.34	0.3
2130	0.37	0.34

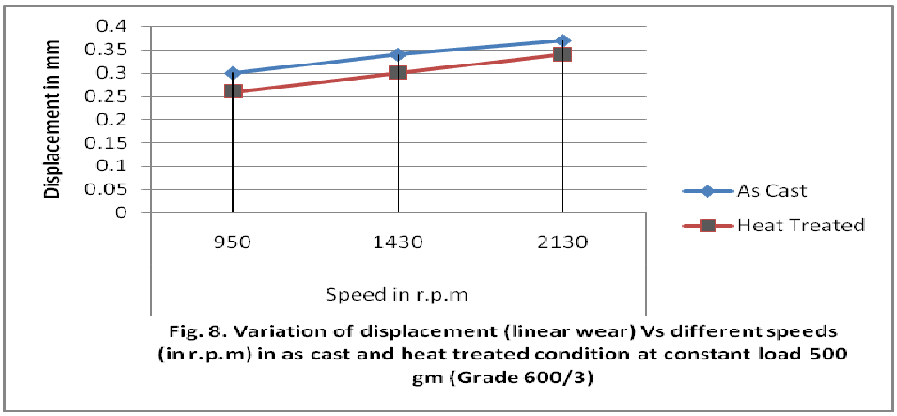

Figure 8: Variation of Displacement (linear wear) Vs Different Speeds (in r.p.m) in as cast Heat Treated Condition at Constant Load 500gm (Grade 600/3).

Figure 8 shows variation of displacement (linear wear) versus different speeds (in r.p.m) in as cast and heat treated state & applied constant load 500 gm. It can be seen from figure linear wear that it is less for heat treated specimen as compared to as cast ones.

Table 5 shows the outcome of applied three speeds on wear test at loads of 300gm, 400gm and 500 gm (constant respectively) in as cast and heat treated sate for a testing time of 20 minutes. It can be seen from table wear that it is less in case of heat treated specimens as compared to as cast ones.

Table 5: Wear Dry Sliding Wear of as Cast and Heat Treated Test Samples for Three Loads (Constant respectively) and Varying Speeds

Load in gms	Speed (in r.p.m)	Condition/State-Wear	
		As Cast Wear(in mm)	Heat Treated, Wear(in mm)
300	950	0.13	0.11
	1430	0.15	0.13
	2130	0.19	0.16
400	950	0.18	0.15
	1430	0.23	0.2
	2130	0.3	0.27
500	950	0.3	0.26
	1430	0.34	0.3
	2130	0.37	0.34

Figure 9 shows variation of displacement (linear wear) versus different speeds (in r.p.m) in as cast and heat treated condition at constant loads of 300gm, 400gm and 500 gm. It can be seen from figure that the linear wear is less for heat treated specimen as compared to as cast ones.

Table 6 The outcome of applied 03 (three) loads on dry sliding wear at constant speed 950 r.p.m in as cast and heat treated state for a testing duration of 20 minutes. It can be seen from table wear that it is less in case of heat treated specimens as compared to as cast ones.

Table 6: Outcome of applied Loads Under Wear Test and Applied Constant Speed 950r.p.m in as Cast and Heat Treated State (after 20 minutes)

Loads in gms	Condition/State-Dry Sliding Wear	
	As cast wear(in mm)	Heat Treated Wear(in mm)
300	0.3	0.26
400	0.35	0.31
500	0.38	0.34

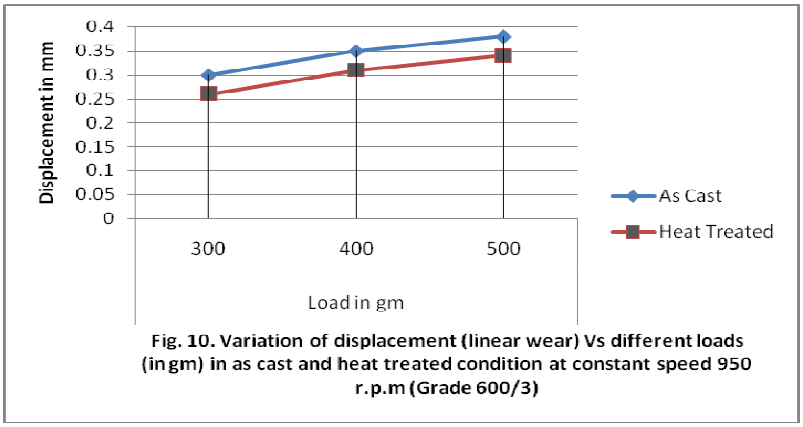

Fig. 10. Variation of displacement (linear wear) Vs different loads (in gm) in as cast and heat treated condition at constant speed 950 r.p.m (Grade 600/3)

Figure 10: Variation of Displacement (linear wear) Vs Different Loads (in gm) in as cast and Heat Treated Condition at Constant Speed 950 r.p.m (Grade 600/3).

Figure 10 shows variation of displacement (linear wear) versus different loads (in gm) in as cast and heat treated state at constant speed 950r.p.m. It can be seen from figure that the linear wear is less for heat treated specimen as compared to as cast ones.

Table 7 shows the outcome of applied loads under wear test at constant speed1430r.p.m in as cast and heat treated state for a testing duration of 20 minutes. It can be seen from table wear that it is less in case of heat treated specimens as compared to as cast ones.

Table 7: Outcome of Applied Loads under Wear Test and Applied Constant Speed 1430 r.p.m in as cast and Heat Treated State (After 20 Minutes)

Loads in gms	Condition/State-Dry Sliding Wear	
	As Cast Wear(in mm)	Heat Treated Wear(in mm)
300	0.33	0.29
400	0.37	0.33
500	0.41	0.38

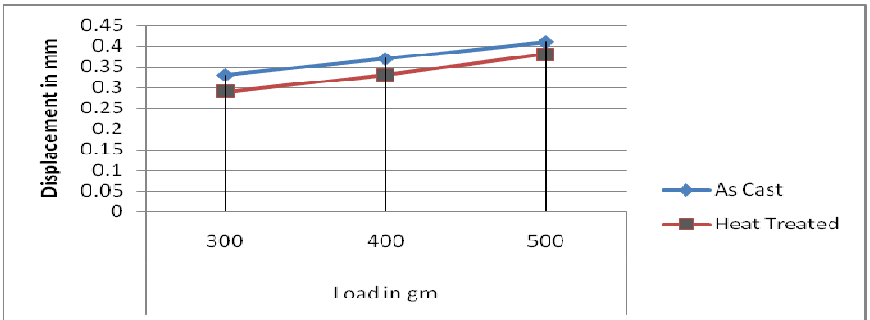

Fig. 11. Variation of displacement (linear wear) Vs different loads (in gm) in as cast and heat treatred condition at constant speed 1430 r.p.m (grade 600/3)

Figure 11: Variation of Displacement (Linear Wear) Vs different loads (in gm) in as Cast and Heat Treated Condition at Constant Speed 1430 r.p.m (grade 600/3).

Figure 11 shows variation of displacement (linear wear) versus different loads (in gm) in as cast and heat treated state at constant speed 1430r.p.m. It can be seen from figure that linear wear is less for heat treated specimen as compared to as cast ones.

Table 8 shows the outcome of applied loads under wear test and applied constant speed 2130r.p.m in as cast and heat treated state for a testing duration of 20 minutes. It can be seen from table wear that it is less in case of heat treated specimens as compared to as cast ones.

Table 8: Outcome of Applied Loads under Wear Test and Applied Constant Speed 2130r.p.m in as Cast and Heat Treated State (after 20minutes)

Loads in gms	Condition/State-Dry Sliding Wear	
	As cast Wear(in mm)	Heat Treated Wear(in mm)
300	0.38	0.35
400	0.41	0.37
500	0.45	0.4

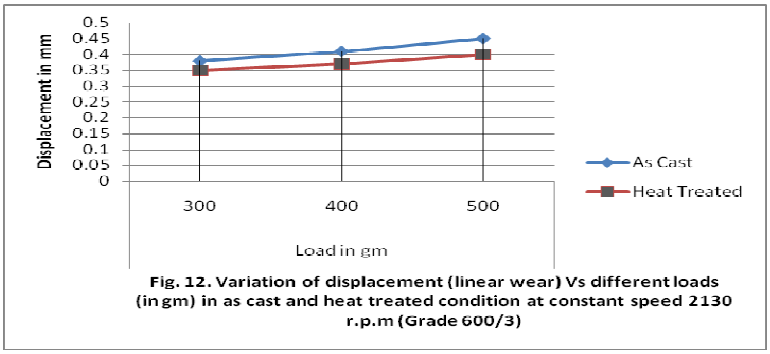

Fig. 12. Variation of displacement (linear wear) Vs different loads (in gm) in as cast and heat treated condition at constant speed 2130 r.p.m (Grade 600/3)

Figure 12: Variation of Displacement (linear Wear) Vs Different Loads (in gm) in as Cast and Heat Treated Condition at Constant Speed 2130 r.p.m (Grade 600/3).

Figure 12 shows variation of displacement (linear wear) versus different loads (in gm) in as cast and heat treated state at constant speed 2130r.p.m. It can be seen from figure linear wear is less for heat treated specimen as compared to as cast ones.

Table 9 shows the effect of three speeds (constant respectively) on dry sliding wear at constant speeds of 950r.p.m, 1430r.p.m and 2130r.p.m in as cast and heat treated state for a testing time of 20 minutes. It can be seen from table wear that it is less in case of heat treated specimens as compared to as cast ones.

Table 9: Dry sliding Wear of as Cast and Heat Treated Samples for Varying Loads & Constant Speeds Respectively

Speed in r.p.m	Load (in gms)	Condition/State-Dry Sliding Wear	
		As Cast Wear(in mm)	Heat Treated Wear(in mm)
950	300	0.3	0.26
	400	0.35	0.31
	500	0.38	0.34
1430	300	0.33	0.29
	400	0.37	0.33
	500	0.41	0.38
2130	300	0.38	0.35
	400	0.41	0.37
	500	0.45	0.4

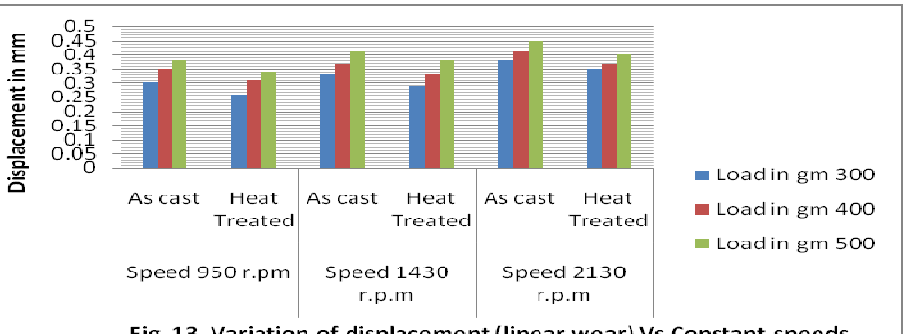

Fig. 13. Variation of displacement (linear wear) Vs Constant speeds (in r.p.m) and different loads (in gm) in as cast and heat treated condition (Grade 600/3)

Figure 13: Variation of displacement (Linear Wear) Vs Constant Speeds (in r.p.m) and different loads (in gm) in as Cast and Heat Treated Condition (Grade 600/3).

Figure 13 shows variation of displacement (linear wear) versus different loads (in gm) in as cast and heat treated state at constant speeds of 950r.p.m, 1430r.p.m and 2130r.p.m. It can be seen from figure that the linear wear is less for heat treated specimen as compared to as cast ones.

3.3 Corrosion

Table 10 shows the corrosion rate (in m.p.y) in as cast and heat treated state at 35°C for testing time of 2 hours to 24 hours. It can be seen from table that the corrosion rate decreases for heat treated specimen as the time of testing increases as compared to as cast ones.

Table 10: Corrosion Rate (in m.p.y) in as Cast and Heat Treated State at 35°C

Condition/state	Corrosion Rate(in m.p.y) - Time (in hours)	
	Corrosion Rate (after 2 hrs.)	Corrosion Rate (after 24 hrs.)
As cast	205	70
Heat Treated	175	40

Table 11 shows the weight loss (in m.g) in as cast and heat treated state at 35°C for testing time of 2 hours to 24 hours. It can be seen from the table that the weight loss is less for heat treated specimen as the time of testing increases as compared to as cast ones.

Table 11: Weight Loss (in M.G) Due to Corrosion in as Cast and Heat Treated State At 35°C

Condition/state	Weight Loss(in m.g) - Time (in hours)	
	Weight loss (after 2 hrs.)	Weight Loss (after 24 hrs.)
As cast	0.25	0.805
Heat Treated	0.2	0.465

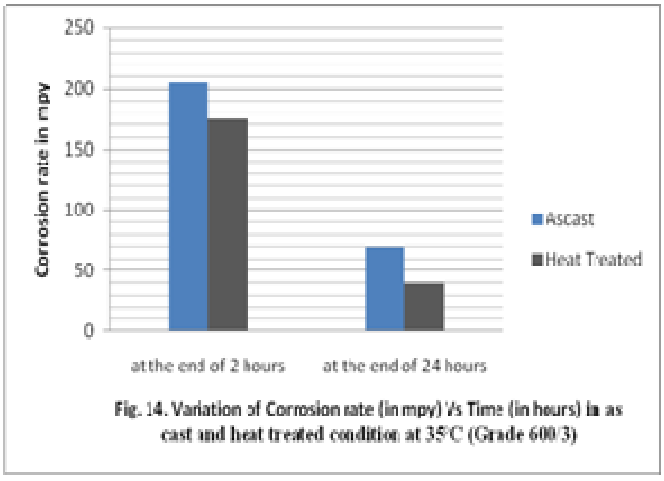

Figure 14: Variation of Corrosion rate (in mpy) Vs Time (in hours) in as cast and heat treated condition at 35°C (Grade 600/3).

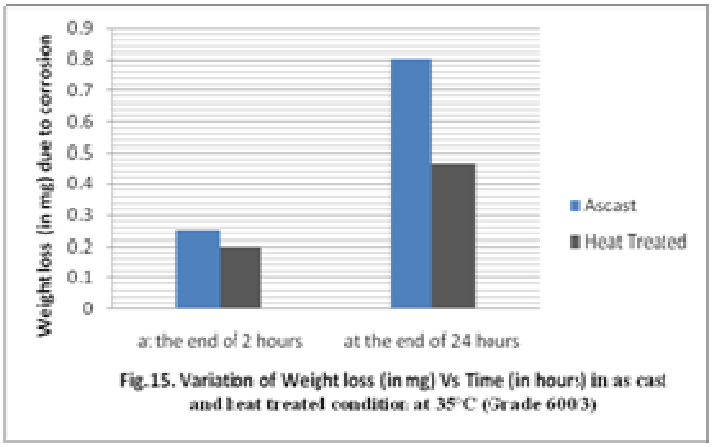

Figure 15: Variation of Weight loss (in mg) Vs Time (in hours) in as Cast and Heat Treated Condition at 35°C (Grade 600/3).

Figure 14 shows the variation of corrosion rate (in m.p.y) versus time (in hrs.) in as cast and heat treated state at a temperature of 35°C. It can be seen from figure that the corrosion rate is less for heat treated testing sample compared to as cast condition.

Figure 15 shows the variation of weight loss (in m.g) versus time (in hrs.) in as cast and heat treated state at a temperature of 35°C. It can be seen from figure that the weight loss is less for heat treated specimen in comparison to as cast state.

Table 12 shows the corrosion rate (in m.p.y) in as cast and heat treated condition at 45°C for testing time of 2 hours to 24 hours. It can be seen from table that the corrosion rate decreases for heat treated specimen as the time of testing increases as compared to as cast ones.

Table 12: Corrosion Rate (in m.p.y) in as Cast and Heat Treated State at 45°C

Condition/state	Corrosion Rate (in m.p.y) - Time (in hours)	
	Corrosion Rate (after 2 hrs.)	Corrosion Rate (after 2 hrs.)
As cast	545	265
Heat Treated	485	194

Table 13 shows the weight loss (in m.g) in as cast and heat treated state at 45°C for testing time of 2 hours to 24 hours. It can be seen from table that the weight loss is less for heat treated specimen as the time of testing increases as compared to as cast ones.

Table 13: Weight Loss (in m.g) due to Corrosion in as Cast and Heat Treated State at 45°C

Condition/state	Weight Loss (in m.g)- Time (in hours)	
	Weight Loss (after 2 hrs.)	Weight Loss (after 2 hrs.)
As Cast	0.53	3.52
Heat Treated	0.51	2.42

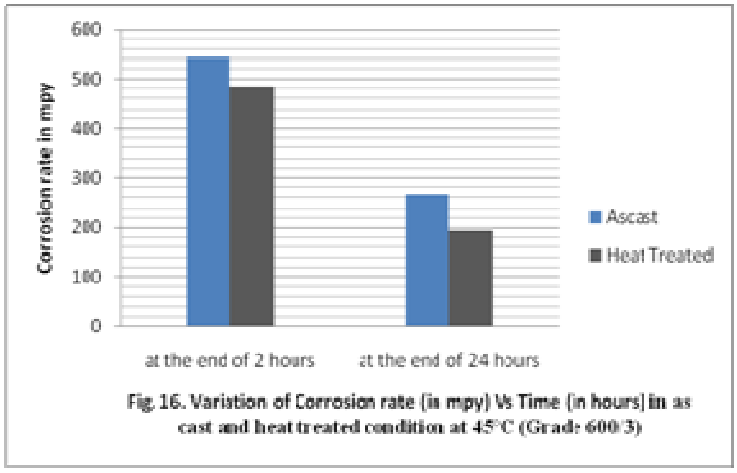

Figure 16: Variation of Corrosion rate (in mpy) Vs Time (in hours) in as Cast and Heat Treated Condition at 45°C (Grade 600/3).

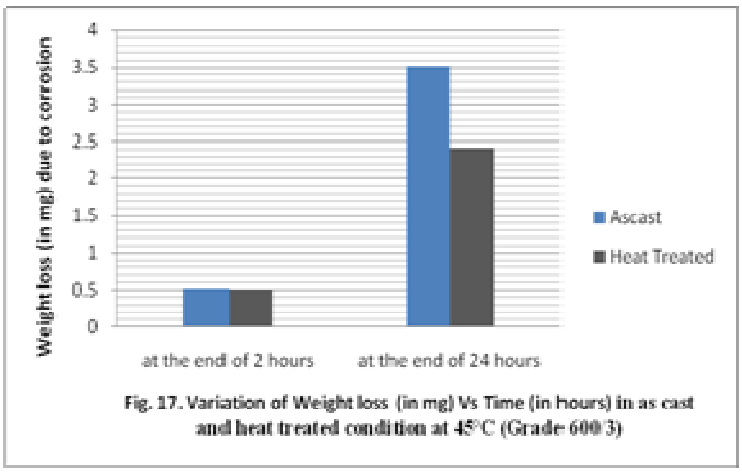

Figure 17: Variation of Weight Loss (in mg) Vs Time (in hours) in as Cast and Heat Treated Condition at 45°C (Grade 600/3).

Figure 16 shows the variation of corrosion rate (in m.p.y) versus time (in hrs.) in as cast and heat treated state at a temperature of 45°C. It can be seen from figure that the corrosion rate is less for heat treated specimen as compared to as cast condition.

Figure 17 shows the variation of weight loss (in m.g) versus time (in hrs.) in as cast and heat treated state at a temperature of 45°C. It can be seen from figure that the weight loss is less for heat treated testing sample in comparison to as cast state.

Table 14 shows corrosion rate at temperature 35°C and 45°C in as cast and heat treated state for testing time of 2 hours. It can be seen from table that the corrosion rate is less for both temperature conditions as compared to as cast condition.

Table 14: Corrosion Rate at Temperature 35°C and 45°C in as Cast and Heat Treated Condition for 2 Hours Testing Time.

Condition/state	Temperature in °C-Corrosion Rate (in m.p.y)	
	Temperature 35°C	Temperature 45°C
As cast	205	545
Heat Treated	175	485

Table 15 shows corrosion rate at temperature 35°C and 45°C in as cast and heat treated state for testing time of 24 hours. It can be seen from table corrosion rate that it is less for both temperature conditions as compared to as cast state.

Table 15: Corrosion Rate at Temperature 35°C and 45°C in as Cast and Heat Treated State for 24 Hours Testing Time.

Condition/state	Temperature in °C-Corrosion Rate (in m.p.y)	
	Temperature 35°C	Temperature 45°C
As cast	70	265
Heat Treated	40	194

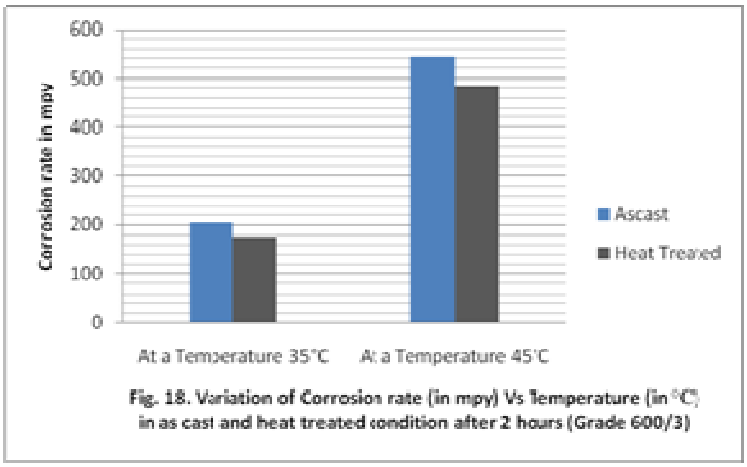

Figure 18: Variation of Corrosion Rate (in mpy) Vs Temperature (in °C) in as Cast and Heat Treated Condition After 2 Hours (Grade 600/3).

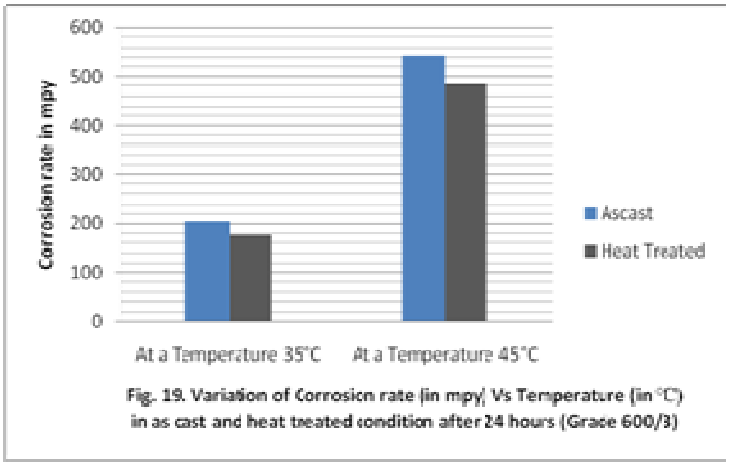

Figure 19: Variation of Corrosion Rate (in mpy) Vs Temperature (in °C) in as Cast and Heat Treated Condition After 24 Hours (Grade 600/3).

Figure 18 and Figure 19 shows corrosion rate at temperature 35°C and 45°C in as cast and heat treated state for testing duration of 2 hours and 24 hours respectively. It can be seen from figure that the corrosion rate is less for both temperature condition as compared to as cast condition.

Table 16 shows weight loss at a temperature 35°C and 45°C in as cast and heat treated condition for testing time of 2hours. It can be seen from table that the weight loss is less for both temperature condition as compared to as cast state.

Table 16: Weight Loss at Temperature 35°C and 45°C in as Cast and Heat Treated State for 2 Hours Testing Time

Condition/State	Temperature in °C-Weight Loss(in m.g)	
	Temperature 35°C	Temperature 45°C
As Cast	0.25	0.53
Heat Treated	0.2	0.51

Table 17 shows that the weight loss at temperature35°C and 45°C in as cast and heat treated state for testing time of 24 hours. It can be seen from table that the weight loss is less for both temperature condition as compared to as cast state.

Table 17: Weight Loss at Temperature 35°C and 45°C in as Cast and Heat Treated State for 24 Hours Testing Time

Condition/State	Temperature in °C-Weight Loss (in m.g)	
	Temperature 35°C	Temperature 45°C
A cast	0.805	3.52
Heat Treated	0.465	2.42

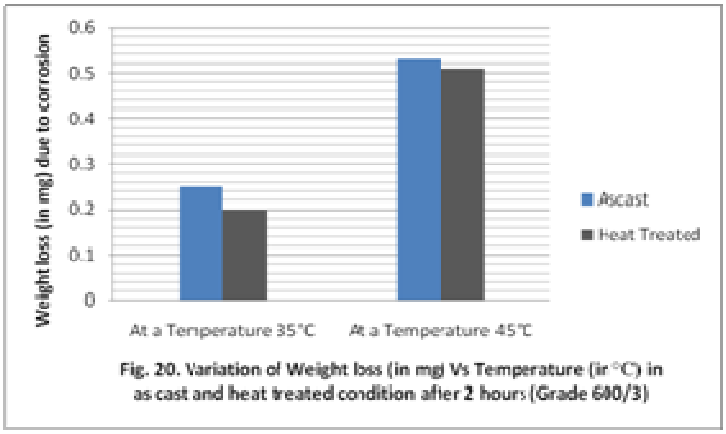

Figure 20: Variation of Weight Loss (in mg) Vs Temperature (in °C) in as Cast and Heat Treated Condition After 2 Hours (Grade 600/3).

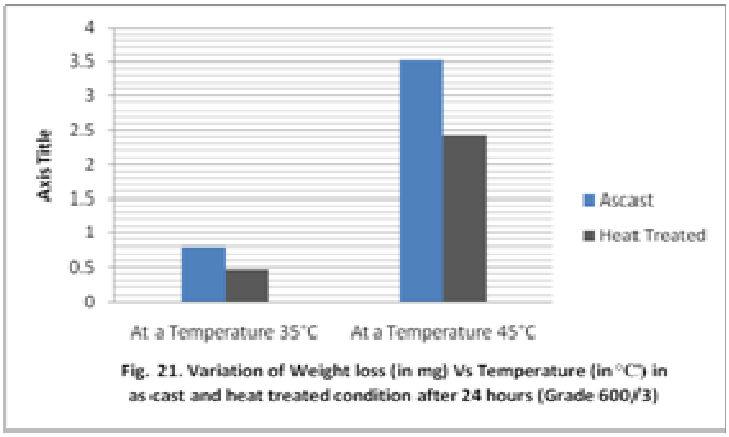

Figure 21: Variations of Weight Loss (in mg) Vs Temperature (in °C) in as Cast and Heat Treated Condition After 24 Hours (Grade 600/3).

Figure 20 and Figure 21 shows weight loss at temperature35°C and 45°C in as cast and heat treated state for testing time of 2 hours and 24 hours respectively. It can be seen from figure that the weight loss is less for both temperature conditions as compared to as cast condition.

4. DISCUSSIONS

4.1 Mechanical Properties

- The change in UTS, percentage elongation values and hardness of the sample tested are indicated in table1. From the table, it is clear that UTS, percentage elongation and Brinell hardness of the heat treated samples are considerably greater than the as-cast test samples. This is because due to the development of bainite during process of autempering treatment in the specimen.
- The impact studies indicate that the impact energy falls in case of heat treated specimen which indicates that specimen becomes brittle during heat treatment process for Izod condition. The decrease in impact energy nearly by 29% as indicted in table 1 & figure 3.
- The impact results for Charpy condition indicate that the energy drops on heat treated specimen. The decrease in impact energy level that is as high as 71%, as indicted in table1 & figure 4. This is due to the type of condition applied for impact studies and habit of sample for test to become brittle during heat treatment process.

4.2 Dry Sliding Wear Characteristics

Change in weight loss at three speeds (i.e. 950r.p.m, 1430r.p.m and 2130r.p.m) and 3 different loads (i.e. 300 gm, 400 gm & 500 gm) were evaluated. Dry sliding wear of as cast specimen is greater in comparison to heat treated specimen for particular speed or applied load. Wear becomes greater with a rise in duration of test. Fall in dry sliding wear for heat treated sample differs in the range of 10 to 15.67%, as compared to as cast specimen, as indicated from table 2 to table 9 and from figure 6 to figure 13.

4.3 Corrosion Characteristics

- The change in corrosion rate and loss of weight at individual temperature state (i.e., 35°C & 45°C) for testing time of 2 hours and 24 hours respectively were examined. Corrosion rate is higher for as cast testing sample in comparison to heat treated testing sample.
- Corrosion rate and weight loss of as cast testing sample is comparatively greater than heat treated state for applied temperatures, 35°C & 45°C and testing time of 2 hours to 24 hours. Corrosion rate falls with a rise in duration of test. Fall in corrosion rate for heat treated sample differs from 14.63 to 42.85% at temperature 35°C and 11 to 26.79% at temperature 45°C with respect to as cast testing sample for testing time of 2 hours and 24 hours respectively, as indicated in Table 10, 12, 14, 15 and Figure 14, 16, 18 ,19.
- Weight loss goes down with a rise in time of testing. Fall in weight loss for heat treated sample differs from 20 to 42.23% at temperature of 35°C and 3.77 to 31.25% at temperature 45°C respect to as cast testing sample for testing time of 2 hours to 24 hours as indicated in Table 11, 13, 16, 17 and Figure 15, 17, 20, 21.

5. CONCLUSIONS

The outcome of above research analysis is mentioned below:

- Mechanical properties in heat treated state in comparison to as cast state increases s given belows:-
  - UTS - 25% increases,
  - %age elongation - 27.88% increases,
  - Hardness values - 10.6% increases.
- Impact study results (for Izod & Charpy condition) indicates that the impact energy falls for heat treated sample in comparison to as cast condition due to the tendency of heat treated specimen to become brittle.
- Dry sliding wear recorded heat-treated state is not greater when compared to as cast ones.
- Corrosion rate values and weight loss values indicate that it is less for heat treated sample in comparison to as cast sample in applied temperatures (i.e.,.35°C & 45°C) for the testing time of 24 hours.

Hence, from above indicated results, it is understandable that by heat treating, the ductile iron provides superior properties and characteristics.

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